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A Bibliography of Triploid Fish, 1943 to 1988

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by

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ABSTRACT

Benfey, T.J. 1989. A bibliography of triploid fish, 1943 to 1988. Can. Tech. Rep. Fish. Aquat. Sci. 1682: 33 p.

This bibliography provides a comprehensive taxonomical listing of publications dealing with auto- and allotriploids of species of fish that are normally dioecious diploids, and includes the method of triploid induction in most cases. A total of 311 references were found (excluding 23 reviews): 173 dealing with 43 species of autotriploids (19 families representing 7 orders) and 66 dealing with 42 examples of allotriploids (6 families, 4 orders). The majority of these references deal with the families Salmonidae (99 on autotriploids and 27 on allotriploids) and Cyprinidae (25 and 31, respectively). The two most frequently encountered species are rainbow trout, Salmo gairdneri (66 on autotriploids and 14 on allotriploids) and grass carp, Ctenopharyngodon idella (13 and 27, respectively).

RÈSUMÈ

Benfey, T.J. 1989. A bibliography of triploid fish, 1943 to 1988. Tech. Rep. Fish Aquat. Sci. 1682: 33 p.

Vous trouverex dans cette bibliographie une liste exhaustive des ouvrages qui traitent des auto et allotriploïdes chez les poissons normalement inclus dans la catégorie des diploïdes dioïques, et qui, dans la plupart des cas, traitent de la méthode de triploidisation. La liste comprend 311 ouvrages (à l'exclusion de 23 examens); 173 traitent de 43 espèces d'autotriploïdes (19 familles, 7 classes) et 66 donnent 42 exemples d'allotriploïdes (6 familles, 4 classes). La majorité des textes portent sur les familles de salmonidés (99 sur les autotriploïdes et 27 sur les allotriploïdes) et les cyprinidés (25 et 31 respectivement). Les deux expèces les plus fréquemment citées sont la truite arc-en-ciel (salmo gairdneri (66 ouvrages sur les autotriploïdes et 14 sur les allotriploïdes) et la carpe herbivore, ctenopharyngodon idella (13 et 27 respectivement).

INTRODUCTION

Sexually maturing fish undergo numerous physiological and behavioural changes that may reduce their value as fish destined for human consumption. Various methods have therefore been devised and investigated to delay or entirely prevent sexual maturation in fish used for aquaculture. One of the most effective of these is the induction of triploidy, because the resulting fish are genetically sterile. A list of review papers dealing with this topic appears in Table 1. The aim of this report is to provide a bibliography of publications dealing with triploid fish.

Natural populations of triploids have evolved in six genera representing three orders of fish. Three of these cases are well documented, and have been reviewed by Schultz (1979) and Purdom (1984): these are in Poecilia and Poeciliopsis (both order Cyprinodontiformes, family Poeciliidae) and Carassius (Cypriniformes, Cyprinidae). The remaining three are recent discoveries in Menidia (Mugiliformes, Atherinidae) (Echelle et al., 1983), Phoxinus (Cyprinidae) (Joswiak et al., 1985; Dawley et al., 1987) and Rutilus (Cyprinidae) (Collares-Pereira, 1987). These fish are always fertile unisexual females that reproduce by atypical means involving gynogenesis or hybridogenesis, and are not included in this bibliography.

Triploid individuals of species that are normally dioecious diploids (autotriploids) are occasionally found among wild fish, and can readily be produced in species for which it is possible to manipulate spawning. A comprehensive list of papers describing or utilizing spontaneously-arisen or experimentally-induced autotriploids appears in Table 2. Virtually all these fish have become triploid by the retention of the second polar body, and thus contain two maternal and one paternal haploid chromosome sets, as do triploid rainbow trout produced by crossing tetraploid females with diploid males (Chourrout and Nakayama, 1987). The notable exceptions are triploid rainbow trout produced by the breeding of tetraploid males with diploid females (Chourrout et al., 1986b; Blanc et al., 1987; Chourrout and Nakayama, 1987; Oliva-Teles and Kaushik, 1987a; Quillet et al., 1988b) or by the dispermic fertilization of haploid eggs after treating the spermatozoa with polyethylene glycol (Ueda et al., 1986). In these cases, the resultant fish have one maternal and two paternal haploid chromosome sets. Induced triploidy can be used to increase the viability of interspecific hybrids (allotriploids), although it is by no means clear why this is so (Chevassus, 1983; Krasznai, 1987; Neavdal and Dalpadado, 1987). A comprehensive list of papers describing or utilizing spontaneously-arisen or experimentally-induced allotriploids appears in Table 3.

Tables 2 and 3 are sorted taxonomically, according to Golvan (1962). Within an individual species (Table 2) or hybrid (Table 3), references are listed chronologically; if more than one reference was published in the same year, they are listed alphabetically. The technique used to induce triploidy has been given in most cases; if the technique was not known, a question mark appears. Many of the papers dealing with grass carp or grass x bighead carp hybrids use fish obtained from a commercial source (J.M. Malone and Sons), and are identified as such, with the brood year given if possible. It should be noted that several of the references

appearing in this bibliography only describe unsuccessful attempts to induce triploidy; this is especially true of earlier publications. It should also be noted that in some cases triploids only served as controls for experiments on induced gynogenesis, and hence many not be described in detail in those papers. For hybrids and for tetraploid (4n) x diploid (2n) crosses, the female parent is always given first.

The bibliography should be virtually complete to the end of 1987, but also includes many 1988 publications. I apologize in advance for any omissions, and hope that they will be brought to my attention. I wish to thank Ed Donaldson, Ted Down, Susan Keller and especially Morva Booth for their help in the compilation of this bibliography.

TABLE 1. General Reviews

Chevassus et al. (1979)
Stanley (1979)
Allen and Stanley (1981b)
Stanley (1981)
Donaldson and Hunter (1982)
Refstie (1982)
Purdom (1983)
Thorgaard (1983)
Yamazaki (1983)
Allendorf and Leary (1984)
Purdom (1984)
Donaldson (1986)
Purdom (1986)
Shelton (1986)
Thorgaard (1986)
Chevassus (1987)
Chourrout (1987)
Donaldson and Benfey (1987)
Nagy (1987)
Shelton(1987)
Thorgaard and Allen (1987)
Benfey and Donaldson (1988)
Chourrout (1988)

TABLE 2. Autotriploids

CHONDROSTEI

Order ACIPENSERIFORMES
Family ACIPENSERIDAE
Genus Acipenser

A. guldenstadti colchicus (Black Sea - Azov Sea sturgeon)
Vasetskii (1967): heat

A. transmontanus (white sturgeon)
Kowtal (1987): heat

TELEOSTEI

Order CLUPEIFORMES
Suborder SALMONOIDEI
Family SALMONIDAE
Genus Oncorhynchus

O. gorbuscha (pink salmon)
Utter et al. (1983): heat
Chernenko (1985): heat
Benfey et al. (1987): [pressure]
Benfey et al. (1988b): pressure
Yamano et al. (1988): pressure

O. keta (chum salmon)
Arai (1984): pressure
Chernenko (1985): colchicine, formalin, heat
Arai (1986): pressure
Seeb et al. (1986): heat
Benfey et al. (1988a): pressure
Seeb et al. (1988): heat

O. kisutch (coho salmon)
Refstie et al. (1982): cold
Utter et al. (1983): heat
Johnson et al. (1984): heat
Chernenko (1985): heat
Johnson et al. (1986): heat
Parsons et al. (1986): heat
Phillips et al. (1986): heat
Seeb et al. (1986): heat
Benfey et al. (1987): [pressure]
Small and Benfey (1987): pressure
Benfey and Donaldson (1988): nitrous oxide
Seeb et al. (1988): heat
Small and Randall (1988): pressure

O. nerka (sockeye salmon)
Chernenko (1968): spontaneous (18/117)

TABLE 2. (cont.)

O. tshawytscha (chinook salmon)
Utter et al. (1983): heat
Johnson et al. (1984): heat
Hill et al. (1985): heat
Phillips et al. (1986): heat
Seeb et al. (1986): heat
Seeb et al. (1988): heat

Genus *Salmo*
S. gairdneri (rainbow trout)
Lieder (1964): colchicine
Cuellar and Uyeno (1972): spontaneous (1/18)
Purdom and Lincoln (1973): cold
Grammeltvedt (1974): spontaenous (1/34)
Refstie et al. (1977): cytochalasin B
Thorgaard and Gall (1979): spontaneous (6/11, not random)
Chourrout (1980): heat
Thorgaard et al. (1981): heat
Chourrout and Quillet (1982): heat
Thorgaard et al. (1982): heat, spontaneous (2/30, not random)
Chevassus et al. (1983): heat
Lincoln and Scott (1983): heat
Scheerer and Thorgaard (1983): heat
Ueda et al. (1983): spontaneous (2/17)
Wright et al. (1983): spontaneous
Yamazaki (1983): pressure
Chevassus et al. (1984): heat
Chourrout (1984): pressure
Lincoln and Bye (1984a): heat
Lincoln and Bye (1984b): review
Lincoln and Scott (1984): heat
Lou and Purdom (1984): ether, heat, pressure
Solar et al. (1984): heat
Sumpter et al. (1984): [heat]
Bolla and Refstie (1985): cytochalasin B
Choubert and Blanc (1985): heat
Dorson and Chevassus (1985): heat
Leary et al. (1985): heat
Okada (1985): pressure
Purdom et al. (1985): heat
Solar and Donaldson (1985): heat
Thorgaard et al. (1985): heat
Allendorf et al. (1986): heat
Almeida (1986): heat
Benfey et al. (1986): heat
Bye and Lincoln (1986): review
Chourrout (1986a): heat
Chourrout (1986b): heat
Chourrout et al. (1986a): review
Chourrout et al. (1986b): breeding (2n X 4n), heat, pressure
Dorson and Chevassus (1986): heat

TABLE 2. (cont.)

S. gairdneri [cont.]
Fauconneau et al. (1986): ?
Forster et al. (1986): heat
Johnstone and Lincoln (1986): heat
Kim et al. (1986): heat
Parsons et al. (1986): heat
Phillips et al. (1986): heat
Shelton et al. (1986): nitrous oxide
Ueda et al. (1986): polyethylene glycol
Benfey et al. (1987): [heat]
Blanc et al. (1987): breeding (2n X 4n), heat
Boulanger (1987): pressure
Chourrout and Nakayama (1987): breeding (2n X 4n) & (4n X 2n), heat
Flajshans and Rab (1987): spontaneous (1/39)
Johnstone et al. (1987): nitrous oxide
Lincoln and Bye (1987): heat
Nakamura et al. (1987): heat
Oliva-Teles and Kaushik (1987a): breeding (2n X 4n), heat
Oliva-Teles and Kaushik (1987b): heat
Quillet et al. (1987): heat
Sakai et al. (1987): pressure
Ueda et al. (1987): pressure
Benfey et al. (1988b): heat
Happe et al. (1988): heat
Quillet et al. (1988a): heat
Quillet et al. (1988b): breeding (2n x 4n), heat

S. mykiss (Kamchatkan trout)
Chernenko (1985): heat

S. salar (Atlantic salmon)
Lincoln et al. (1974): cold
Refstie et al. (1977): cytochalasin B
Allen and Stanley (1979): cytochalasin B
Allen and Stanley (1981a): cytochalasin B
Allen (1983): cytochalasin B
Holmefjord et al. (1983): heat
unpubl. data cited by Purdom (1983): heat
Benfey and Sutterlin (1984a): heat
Benfey and Sutterlin (1984b): [heat]
Benfey and Sutterlin (1984c): heat
Benfey and Sutterlin (1984d): heat, pressure
Benfey et al. (1984): heat
Bolla and Refstie (1985): cytochalasin B
Graham et al. (1985): heat
Johnstone (1985): heat
Fox et al. (1986): heat
Glebe et al. (1986): heat
Johnstone (1987): heat, pressure
Small and Benfey (1987): pressure
Sutterlin et al. (1987): heat

TABLE 2. (cont.)

S. trutta (brown trout)
Scheerer and Thorgaard (1983): heat
Arai and Wilkins (1987): heat

Genus Salvelinus
S. alpinus (Arctic char)
Glebe et al. (1986): heat

S. fontinalis (brook char)
Allen and Stanley (1978): spontaneous
Smith and Lemoine (1979): colchicine
Lemoine and Smith (1980): cold
Scheerer and Thorgaard (1983): heat
unpubl. data cited by Boulanger (1987): pressure

S. leucomaenis (Japanese char)
Arai (1984): pressure

Family PLECOGLOSSIDAE
Genus Plecoglossus
P. altivelis (ayu)
Taniguchi et al. (1985): cold
Taniguchi et al. (1986a): cold
Ueno et al. (1986): cold
Taniguchi et al. (1987): cold
Taniguchi et al. (1988): pressure

Family COREGONIDAE
Genus Coregonus
C. lavaretus (gwyniad)
Svardson (1945): cold, spontaneous (1/?)

Suborder ESOXOIDEI
Family ESOCIDAE
Genus Esox
E. lucius (northern pike)
Lieder (1964): cold

Order CYPRINIFORMES
Suborder CHARACOIDEI
Family CHARACIDAE
Genus Astyanax
A. schubarti
Morelli et al. (1983): spontaneous (1/21)

Family ANOSTOMIDAE
Genus Curimata
C. modesta
Venere and Junior (1985): spontaneous (1/10)

TABLE 2. (cont.)

Family GYMNOTIDAE
Genus Eigenmannia
Eigenmannia sp.
De Almeida Toledo et al. (1985): spontaneous (1/6)

Suborder CYPRINOIDEI
Family CYPRINIDAE
Genus Aristichthys
A. nobilis (bighead carp)
Allen and Stanley (1983): spontaneous (1/38)

Genus Ctenopharyngodon
C. idella (grass carp)
Allen and Stanley (1983): spontaneous (1/38)
Wattendorf and Anderson (1984): ? (Malone)
Cassani and Caton (1985): cold, cytochalasin B, heat
Allen and Wattendorf (1986): ? (Malone)
Allen et al. (1986): ?
Burns et al. (1986): ?
Cassani and Caton (1986a): heat, pressure
Cassani and Caton (1986b): ?
Wattendorf (1986): ?
Wiley and Wike (1986): ? (Malone)
Allen and Wattendorf (1987): review
Clugston and Shireman (1987): review
Thompson et al. (1987): cold, heat

Genus Cyprinus
C. carpio (carp)
Makino and Ozima (1943): cold
Ojima and Makino (1978): cold
Gervai et al. (1980): cold
Meriwether (1980): colchicine, cold
Al-Sabti et al. (1983): spontaneous (1/13)
Ueno (1984): cold
Taniguchi et al. (1986b): cold
Wu et al. (1986): cold

Genus Gnathopogon
G. elongathus caerulescens (willow gudgeon)
Ueno (1985): cold

Genus Hesperoleucus
H. symmetricus (California roach)
Gold and Avise (1976): spontaneous (1/9)

Genus Pimephales
P. promelas (fathead minnow)
Gold (1986): spontaneous (1/15)

TABLE 2. (cont.)

Genus Rhodeus
R. ocellatus ocellatus (rose bitterling)
Ueno and Arimoto (1982): cold

Family COBITIDAE
Genus Misgurnus
M. anguillicaudatus (Japanese common loach)
Ojima and Takai (1979): spontaneous (1/80)
Suzuki et al. (1985): cold
Chao et al. (1986): cold

M. fossilis (loach)
Vasetskii et al. (1984): pressure

Family SILURIDAE
Genus Silurus
S. glanis (European catfish)
Krasznai et al. (1984c): cold
Krasznai and Marian (1986): cold

Family AMEIURIDAE
Genus Ictalurus
I. punctatus (channel catfish)
Wolters et al. (1981): cold
Wolters et al. (1982a): cold
Wolters et al. (1982b): cold
Chrisman et al. (1983): cold
Bidwell et al. (1985): heat
Bidwell et al. (1986): heat

Family CLARIIDAE
Genus Clarias
C. gariepinus (African catfish)
Henken et al. (1987): cold
Richter et al. (1987): cold

Order GASTEROSTEIFORMES
Family Gasterosteidae
Genus Gasterosteus
G. aculeatus (threespine stickleback)
Swarup (1956): cold, heat
Swarup (1959a): cold, heat
Swarup (1959b): cold, heat
Swarup (1959c): cold, heat

Order CYPRINODONTIFORMES
Family CYPRINODONTIDAE
Genus Oryzias
O. latipes (medaka)
Naruse et al. (1985): heat

TABLE 2. (cont.)

O. melastigma
Sriramulu (1962): colchicine

Order PERCIFORMES
Suborder PERCOIDEI
Family PERCIDAE
Genus Perca
P. fluviatilis (perch)
Lieder (1964): colchicine, cold

Family CICHLIDAE
Genus Oreochromis [=Tilapia]
O. aureus
Valenti (1975): cold, heat
Don and Avtalion (1986): heat
Penman et al. (1987a): heat
Penman et al. (1987b): heat
Don and Avtalion (1988): cold, heat

O. mossambicus
Pandian and Varadaraj (1987): heat
Penman et al. (1987a): heat
Penman et al. (1987b): heat
Varadaraj and Pandian (1988): colchicine, cold, cytochalasin B, ether, heat, pressure

O. niloticus
Chourrout and Itskovich (1983): heat
Shah and Beardmore (1986): heat
Penman et al. (1987a): heat
Penman et al. (1987b): heat
Don and Avtalion (1988): cold, heat

Order PLEURONECTIFORMES
Suborder PLEURONECTOIDEI
Family PARALICHTHYIDAE
Genus Paralichthys
P. olivaceus (hirame)
Tabata et al. (1986): cold

Family PLEURONECTIDAE
Genus Liopsetta
L. putnami (smooth flounder)
unpubl. data cited by Hoornbeek and Burke (1981): cold

Genus Pleuronectes
P. platessa (plaice)
Purdom (1972): cold
Purdom et al. (1976): cold
Lincoln (1981a): cold
Lincoln (1981b): cold

Genus Pseudopleuronectes

P. americanus (winter flounder)

Hoornbeek and Burke (1981): cold

TABLE 3. Allotriploids

TELEOSTEI

Order CLUPEIFORMES
  Suborder SALMONOIDEI
    Family SALMONIDAE
      Genus Oncorhynchus
        O. gorbuscha (pink salmon) X O. tshawytscha (chinook salmon)
        Utter et al. (1983): heat
          X Salvelinus leucomaenis (Japanese char)
        Yamano et al. (1988): pressure

        O. keta (chum salmon) X O. kisutch (coho salmon)
        Seeb et al. (1986): heat
        Seeb et al. (1988): heat
          X O. tshawytscha (chinook salmon)
        Seeb and Seeb (1986): heat
        Seeb et al. (1986): heat
        Seeb et al. (1988): heat
          X Salvelinus fontinalis (brook char)
        Arai (1986): pressure
          X Salvelinus leucomaenis (Japanese char)
        Arai (1984): pressure

        O. kisutch (coho salmon) X O. keta (chum salmon)
        Seeb et al. (1986): heat
        Seeb et al. (1988): heat
          X O. nerka (sockeye salmon)
        Benfey and Donaldson (1988): [pressure]
          X O. tshawytscha (chinook salmon)
        Seeb et al. (1986): heat
        Benfey and Donaldson (1988): [pressure]
        Seeb et al. (1988): heat
          X Salmo gairdneri (rainbow trout)
        Parsons et al. (1986): heat

        O. nerka (sockeye salmon) X O. kisutch (coho salmon)
        Benfey and Donaldson (1988): [pressure]

        O. tshawytscha (chinook salmon) X O. gorbuscha (pink salmon)
        Utter et al. (1983): heat
          X O. keta (chum salmon)
        Seeb et al. (1986): heat
        Seeb et al. (1988): heat
          X O. kisutch (coho salmon)
        Seeb et al. (1986): heat
        Seeb et al. (1988): heat

TABLE 3. (cont.)

Genus Salmo

S. clarki (cutthroat trout) X S. gairdneri (rainbow trout)
Rohrer and Thorgaard (1986): heat

S. gairdneri (rainbow trout) X Oncorhynchus kisutch (coho salmon)
Chevassus et al. (1983): heat
Dorson and Chevassus (1985): heat
Dorson and Chevassus (1986): heat
Parsons et al. (1986): heat
Quillet et al. (1987): heat
Quillet et al. (1988a): heat
Quillet et al. (1988b): heat
X S. clarki (cutthroat trout)
Rohrer (1982; cited by Rohrer and Thorgaard, 1986): heat
X S. salar (Atlantic salmon)
Purdom et al. (1985): heat
X S. trutta (brown trout)
Chevassus et al. (1983): heat
Scheerer and Thorgaard (1983): heat
Quillet et al. (1987): heat
Quillet et al. (1988a): heat
X Salvelinus fontinalis (brook char)
Capanna et al. (1974): spontaneous
Chevassus et al. (1983): heat
Scheerer and Thorgaard (1983): heat
Ueda et al. (1984): spontaneous
Dorson and Chevassus (1986): heat
Quillet et al. (1988a): heat
X Thymallus thymallus (grayling)
Chourrout (1986a): heat
Chourrout (1986c): heat

S. salar (Atlantic salmon) X S. trutta (brown trout)
Svardson (1945): cold, spontaneous (1/?)
Holmefjord et al. (1983): heat
X Salvelinus alpinus (Arctic char)
Holmefjord et al. (1983): heat
Glebe et al. (1986): heat

S. trutta (brown trout) X S. gairdneri (rainbow trout)
Scheerer and Thorgaard (1983): heat
Purdom et al. (1985): heat
X Salvelinus fontinalis (brook char)
Scheerer and Thorgaard (1983): heat
Scheerer et al. (1987): heat

(S. trutta X S. salar hybrid) X S. salar (Atlantic salmon)
Johnson and Wright (1986): spontaneous
X Salvelinus fontinalis (brook char)
Johnson and Wright (1986): spontaneous

TABLE 3. (cont.)

Genus Salvelinus
S. fontinalis (brook char) X Salmo gairdneri (rainbow trout)
Scheerer and Thorgaard (1983): heat
X Salmo trutta (brown trout)
Scheerer and Thorgaard (1983): heat

S. leucomaenis (Japanese char) X Oncorhynchus keta (chum salmon)
Arai (1984): pressure

Order CYPRINIFORMES
Suborder CHARACOIDEI
Family CHARACIDAE
Genus Colossoma
C. macropomum X C. mitrei
De Almeida-Toledo et al. (1987): spontaneous (1/4)

Suborder CYPRINOIDEI
Family CYPRINIDAE
Genus Ctenopharyngodon
C. idella (grass carp) X Aristichthys nobilis (bighead carp)
Marian and Krasznai (1978): spontaneous
Beck et al. (1980): spontaneous (Malone, 1979 brood)
Cassani (1981): spontaneous (Malone, 1979 brood)
Kilambi and Zdinak (1981): spontaneous
Sutton et al. (1981): spontaneous
Beck and Biggers (1982): spontaneous (Malone, 1979 & 1980 broods)
Kilambi and Zdinak (1982): spontaneous
Magee and Philipp (1982): spontaneous (Malone, 1979, 1980 & 1981 broods)
Allen (1983): spontaneous (Malone, ? brood)
Allen and Stanley (1983): spontaneous (Malone, 1981 brood)
Barker et al. (1983): spontaneous (Malone, 1980 brood)
Beck and Biggers (1983a): spontaneous (Malone, ? brood)
Beck and Biggers (1983b): spontaneous (Malone, 1980 brood)
Beck et al. (1983): spontaneous (Malone, ? brood)
Cassani and Caton (1983): spontaneous (Malone, 1979 brood)
Shireman et al. (1983): spontaneous
Wattendorf and Shafland (1983; cited by Wattendorf and Anderson, 1984): spontaneous
Young et al. (1983): spontaneous
Beck et al. (1984): spontaneous (Malone, 1980 brood)
Cassani et al. (1984): spontaneous (Malone, 1979, 1980 & 1981 broods)
Krasznai et al. (1984a): spontaneous
Krasznai et al. (1984b): spontaneous
Bettoli et al. (1985): spontaneous (Malone, ? brood)
Kilambi and Galloway (1985): spontaneous (Malone, ? brood)
Wiley and Wike (1986): spontaneous (Malone, ? brood)
Wiley et al. (1986): spontaneous (Malone, 1979 brood)
X Megalobrama terminalis
Liu (1987): spontaneous

TABLE 3. (cont.)

Genus Cyprinus
C. carpio (carp) X Ctenopharyngodon idella (grass carp)
Vasil'ev et al. (1975): spontaneous
Stanley (1976): spontaneous
Stanley et al. (1976): spontaneous
X Hemiculter eigenmanni
Vasil'ev et al. (1975): spontaneous

Order PERCIFORMES
Suborder PERCOIDEI
Family CENTRARCHIDAE
Genus Lepomis
(L. gibbosus X L. cyanellus hybrid) X L. cyanellus (green sunfish)
Dawley et al. (1985): spontaneous
Dawley (1987): spontaneous
X L. gibbosus (pumpkinseed)
Dawley et al. (1985): spontaneous
X L. macrochirus (bluegill)
Dawley (1987): spontaneous

Family CICHLIDAE
Genus Oreochromis [=Tilapia]
O. aureus X O. niloticus
Don and Avtalion (1988): heat

O. niloticus X O. aureus
Don and Avtalion (1988): heat
X O. rendalli
Chourrout and Itskovich (1983): heat

Order PLEURONECTIFORMES
Suborder PLEURONECTOIDEI
Family PLEURONECTIDAE
Genus Pleuronectes
P. platessa (plaice) X Platichthys flesus (flounder)
Purdom (1972): cold
Purdom (1976): cold
Lincoln (1981a): cold
Lincoln (1981b): cold
Lincoln (1981c): cold
X (P. platessa X Platichthys flesus hybrid)
Purdom (1972): cold

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